1956

Present status of the Rappahannock River for oyster culture

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Because two serious oyster mortalities have occurred in the Rappahannock River within the past eight years, neither of which has been explained to the satisfaction of all parties, there is considerable apprehension concerning the existing industrial and domestic contributions of pollution to the river, and an understandable feeling that the waste load should be reduced -- not increased.

The mortality of 1949 was not explained, primarily because it was not discovered immediately, and the conditions that had led to it were long since gone when scientific investigations began. The 1955 mortality, on the other hand, though it brought catastrophic losses to many planters, paid valuable dividends in scientific knowledge, for the oyster planters, alerted to watch for signs of trouble, found the phenomenon while it was still underway and brought the biologists into action within a few days of the critical period.

Past experience, and the lessons learned from the 1949 calamity, scanty though they were, had led the scientists to believe that the troubles were caused primarily by natural forces, and not by industrial or domestic pollution. Early experience with the mortality of 1955 only served to confirm these suspicions, but the opinions of the biologists were not popular with most oystermen, who believed firmly that the wastes from the plant of the American Viscose Corporation at Fredericksburg were the cause of their troubles. The biologists, while they recognized this possibility, and had considered the various ways in which the harmful components of these wastes could be translated in significant quantities to the oyster grounds, 50 or more miles away, saw so many facts that opposed this opinion that they were unable to support the popular view, however tempting such a stand would have been.

Realizing that their conclusions were not received favorably, and recognizing that the scientific evidence, though impressive, was by no means conclusive (for scientific evidence seldom is), the Virginia Fisheries Laboratory called for help from outside sources. The impressive response that was received has not been generally recognized, and few people realized how much assistance Virginia received from these scientists: David H. Wallace, Director of the Oyster Institute of North America; Francis Beaven, of the Chesapeake Biological Laboratory, Solomons, Maryland; James B. Engle, of the U. S. Shellfisheries

Laboratory, Annapolis, Maryland; Dr. A. F. Chestnut, Director of the Institute of Fisheries Research, Morehead City, N. C.; G. Robert Lunz, Director of the Bears Bluff Laboratories, Wadmalaw Island, S. C.; Dr. J. G. Mackin, of the Texas A. & M Research Foundation; and Dr. D. W. Pritchard, of the Chesapeake Bay Institute, who served without compensation, and at considerable inconvenience, placing their knowledge, experience, and judgment at the disposal of the State. It is worth mentioning here also that although the travel expenses of these scientists were guaranteed by the Virginia Commission of Fisheries, through the courtesy of the Hon. Charles M. Lankford, Jr., all submitted minimum expense accounts, and some presented no claims whatever.

The Scientific Evidence

The Committee agreed with the conclusions of the Virginia Fisheries Laboratory that the deaths were brought about by changes in the environment caused by the heavy rainfall and unusually high river runoff from hurricanes Connie and Diane. Fresh water probably had some direct effect in causing a kill, especially in certain areas, but the suddenness of the first wave of death, and the distribution of the deaths with the depth of water, together with the results of extensive chemical analyses of the river water, pointed to a depletion of dissolved oxygen, perhaps leading to the production of hydrogen sulphide, as the major cause.

It has been known for many years that in the warmest part of the summer the deeper waters in the middle and upper part of Chesapeake Bay often become completely devoid of oxygen. This is caused by the gradual utilization of the oxygen by bacteria and other marine organisms in the relatively heavy salty water near the bottom, as it moves slowly up the Bay and up the estuaries. The activity of these oxygen users is speeded up as the water temperature increases, hence the situation becomes most acute during hot spells. When this zone of water devoid of oxygen increases in volume and invades the shallower waters, animals may be caught and killed before they can escape. The most striking example is the mortality of crabs in pots that commonly occurs in the critical areas. Oysters caught in such a body of water, since they cannot move, would be particularly vulnerable.

It has not been fully recognized until recently that this phenomenon occurs regularly in the lower reaches of most of the large estuaries tributary to Chesapeake Bay. Attention was focused on this

featured by the 1955 investigations, and since that time the condition has been examined in some detail in the Rappahannock River, especially in the summer and fall of 1956, by the Chesapeake Bay Institute. Some attention has been paid also to the other major rivers, and all the available past information has been examined closely.

Figure 1 represents a vertical section along the main channel of the Rappahannock River from the mouth at Windmill Point to Fredericksburg, a distance of approximately 95 nautical miles. The vertical scale is greatly exaggerated, for the greatest depth is only a very small fraction of the total length of the river, and consequently the bottom appears to be much more irregular than it actually is. The line representing the bottom has been very much smoothed, however, so that only the major features remain. These were retained since they may have some bearing on the oxygen pattern. The distribution of dissolved oxygen illustrated in Figure 1 has been derived from the results of several cruises, to show a typical condition in late summer under normal conditions. Note that two regions of low oxygen are present, and that these are separated by an extensive area in which the water is well-aerated. The upper zone of depletion is definitely connected with the discharge of industrial and domestic wastes from the Fredericksburg area, but the lower zone almost as definitely is not. Note also that the region of poorest oxygen conditions lies in the stretch of river between Bowlers Rock and Hoghouse Rock, exactly the region in which the most serious oyster losses occurred in 1949 and 1955. Note also, however, that at depths of 30 feet or less the dissolved oxygen supply is quite adequate. It is not too well known how much oxygen depletion the oyster can survive, and the temperature and duration of exposure certainly are important factors, but it is not unreasonable to assume that the critical level probably lies well below 2 milliliters per liter. Most of the important oyster grounds are at depths not greater than 20 feet, where usually the oxygen supply, though poor, is not critical.

The typical situation illustrated in Figure 1 is by no means the worst that may occur in the Morattico area. For example, on September 7, 1955, when the mortality had ceased, there was less than 1 ml/L of oxygen at a depth of 20 feet opposite Smoky Point. Again in the period 20 - 22 August 1956, an extensive volume of water in the channel contained less than 1 ml/L oxygen, and the oxygen-poor layers reached almost to the surface at Morattico, where there were less than 3 ml/L at a depth of 10 feet. Records from the Rappahannock River back to September 1951 show that this oxygen sag in the region of Morattico is a normal feature of these waters in summer.

Samples taken at weekly intervals in September 1955 show how the lower part of the Rappahannock River recovered from the critical condition that must have existed at the time of the major mortalities. On 8 September 1955, at a depth of 30 feet, the water contained only about three-tenths of a milliliter of oxygen per liter; by 27 September 1955 the lowest reading at the same depth was about 2 ml/L.

In 1956, a relatively cool summer, a depletion of oxygen existed in the same region as early as 19 July. The condition deteriorated steadily until the end of August, when opposite Morattico there was almost no oxygen in the water at depths greater than 25 feet. By mid-September, however, a substantial recovery had taken place.

The evidence for the Rappahannock River itself perhaps might never be completely convincing if there were not considerable parallel information from other rivers. For example, on 27 September 1955, in the Corrotoman River, the dissolved oxygen content of the water declined steadily from the mouth to the upper reaches. At its junction with the Rappahannock its waters at all depths contained 3 ml/L or more. Five miles upstream, however, less than 2 ml/L existed at 10 feet and only 1 ml/L at 15 feet.

A similar phenomenon seems to be a feature of the lower Potomac River in summer. Data at hand show a substantial reduction of the oxygen level in July and September 1949, July 1950, and September 1955. We do not yet have information for the upper reaches of this river, but the available cruises show that in some years at least a recovery takes place upstream beyond a point 25 miles above the mouth. Thus the low oxygen zone in the Potomac is situated at almost the same distance above the mouth as is the corresponding zone in the Rappahannock.

Data from the York and James Rivers are too scanty to permit definite conclusions, but here also there are indications of oxygen sags in the lower reaches. It is particularly interesting that the area from Gloucester Point to West Point gave low dissolved oxygen readings at the beginning of September 1955 at the time when the Rappahannock and Potomac Rivers also were in poor condition.

Conclusions

A condition exists in upper Chesapeake Bay and in the lower parts of the estuaries, especially the Rappahannock and Potomac Rivers, whereby the dissolved oxygen content of the deeper waters becomes

seriously depleted in summer and fall. Hot weather and unusually heavy river runoff seem to aggravate the condition. There is no clear evidence that these conditions are associated with the discharge of industrial or domestic wastes, although the possibility cannot yet be denied entirely. Our knowledge of the circulation of fresh and salt water in tidal estuaries provides an explanation based completely on natural phenomena.

In an area like the lower Rappahannock, where the major region of oyster planting unfortunately coincides with the critical zone for oxygen, environmental conditions are in a precarious balance which may require only a moderate intensification to bring disaster. The absence of major mortalities prior to 1949 is somewhat puzzling, but we must remember that the number of acres under lease has increased in the last decade, and previous mortalities from the same causes may not have been recognized as major catastrophes because the grounds were more scattered, and fewer marginal grounds were planted. It is also significant, perhaps, that before the State Water Control Board was founded in 1946, and the Virginia Fisheries Laboratory in 1940, the oyster industry had no scientific assistance in their own State that was available on short notice. Some features of the large-scale oyster mortality of 1930 in Mobjack Bay and the lower York River suggest that this may not have occurred in winter, as has been commonly supposed, and that oxygen depletion may have been a contributing factor.

The critical areas are fairly well defined now, and information should accumulate rapidly in the future. Oystermen who plant in these areas must recognize the risk that they are taking, and adjust their operations and their finances to compensate for these occasional heavy losses. The upper Rappahannock is an ideal oyster growing area in many respects, and usually yields there are considerably higher than on the grounds in the lower part of Chesapeake Bay. With proper management of their operations the planters should be able to avoid the crippling losses that some experienced in 1955.

The establishment of new industries that propose to discharge oxygen-demanding wastes into these areas, and the effects of urban expansion, should be considered carefully in the light of these facts. A significant feature of the circulation of water in the lower parts of the estuaries is that the deeper more saline water seldom can replenish its oxygen supply in summer, for it is sealed off from the atmosphere by the layer of lighter, fresher water at the surface. Thus the decay

of organic matter will steadily reduce the amount of dissolved oxygen in these waters until something happens to provide a fresh supply. In the fresh water section of the estuary, on the other hand, there are no serious barriers to a replenishment of the oxygen supply, and it is obvious that in the zone of recovery below the polluted area near Fredericksburg, the oxygen supply is replenished more rapidly than it is consumed.

We know so little at present of the tolerance of oysters to low oxygen, and so little of the margin of safety between the normal summer depletion of oxygen in the region, and the critical point for oyster survival, that the addition of new oxygen-demanding substances should be made with caution. Every effort should be made to ensure that the natural load of the river is not increased significantly.

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November 26, 1956